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(56) Documents Cited
GB 1147459 A EP 0745965 A EP 0697301 A
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(54) Abstract Title
A vehicle speed controller

(57) A controller for a vehicle engine includes a receiver arranged to receive a signal from outside the vehicle and output a current-vehicle-speed-limit signal to a comparator. The comparator compares the current-vehicle-speed-limit signal to the current-vehicle-speed signal and outputs a control signal to reduce engine torque if the vehicle speed is greater than the current speed limit.

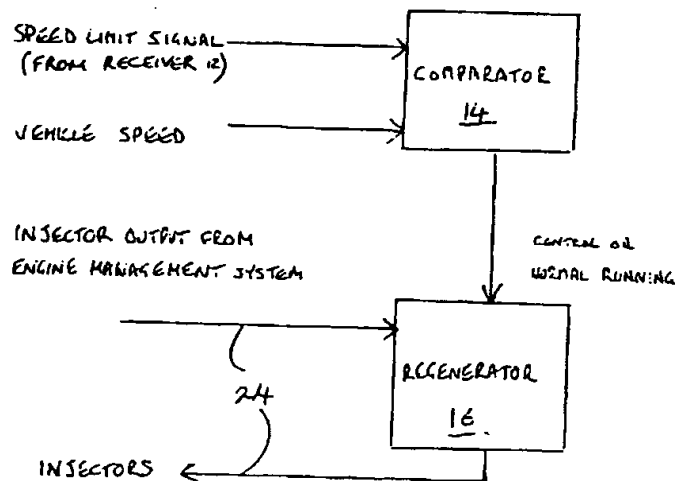


FIGURE 2

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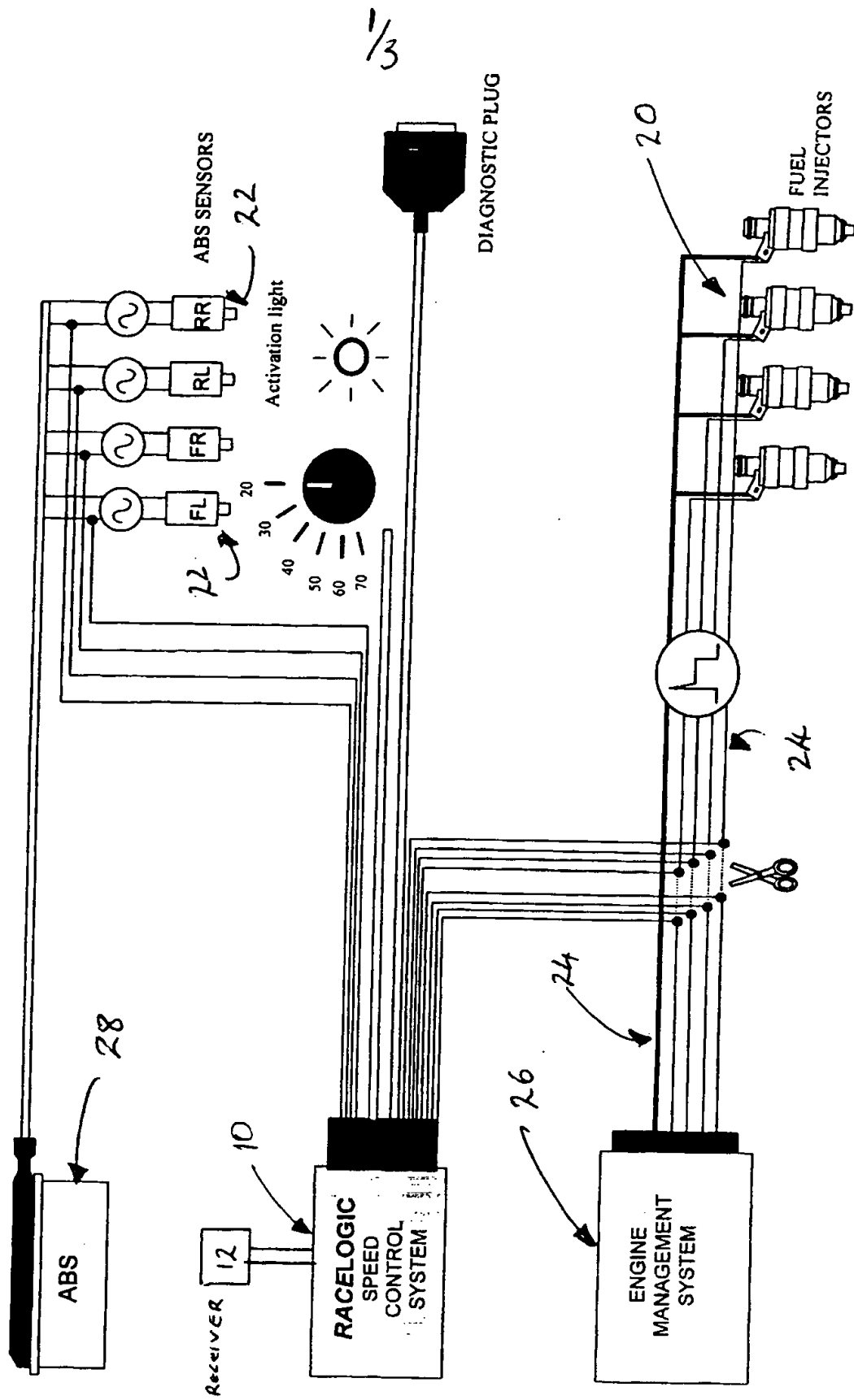


FIGURE 1

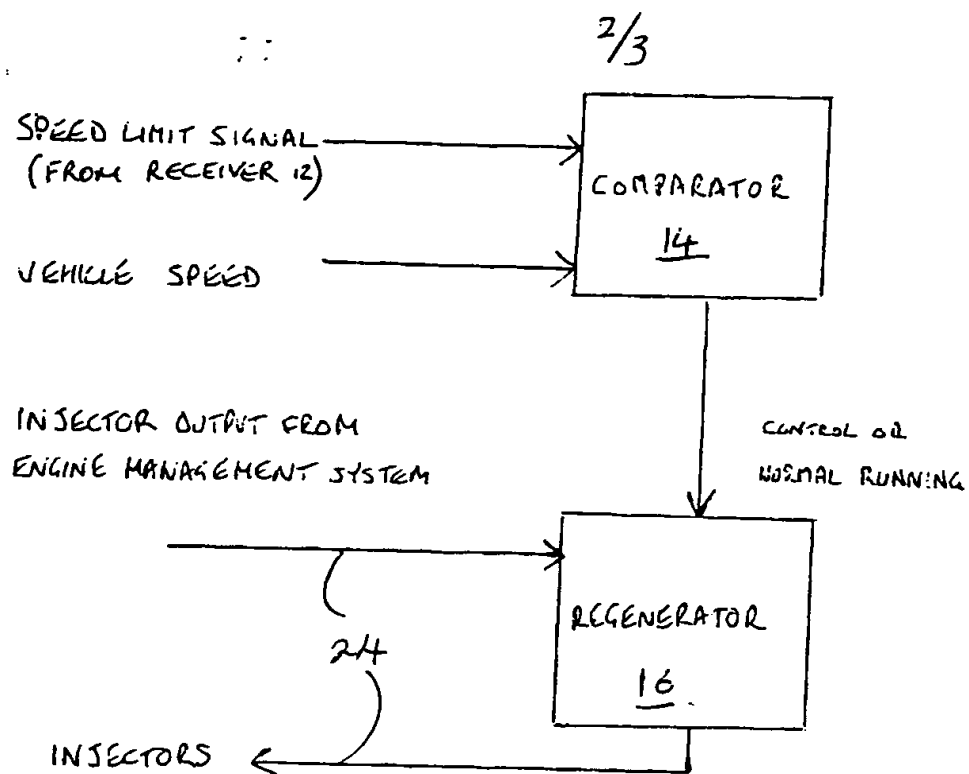


FIGURE 2

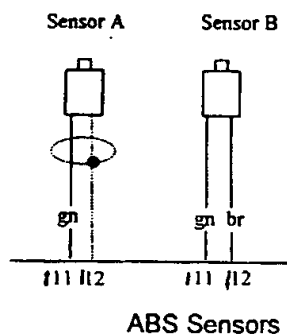


FIGURE 3

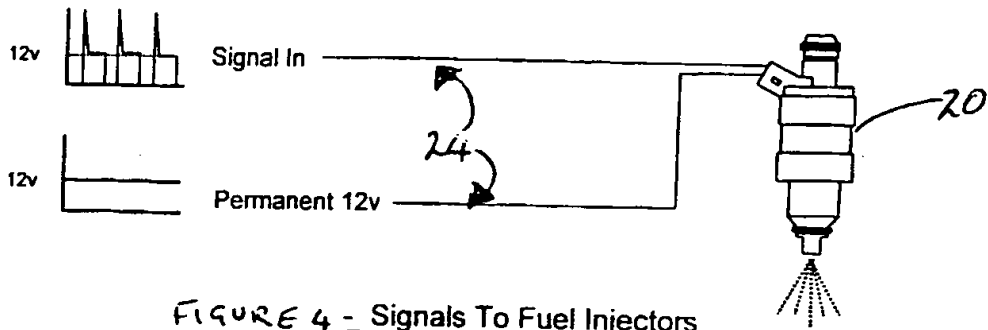


FIGURE 4 - Signals To Fuel Injectors

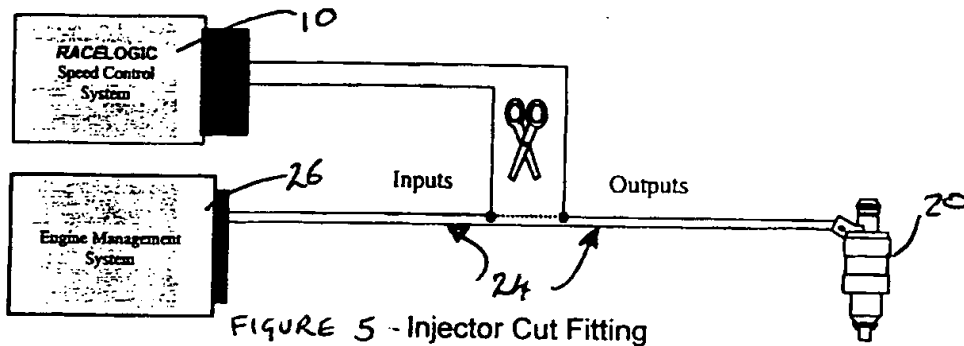


FIGURE 5 - Injector Cut Fitting

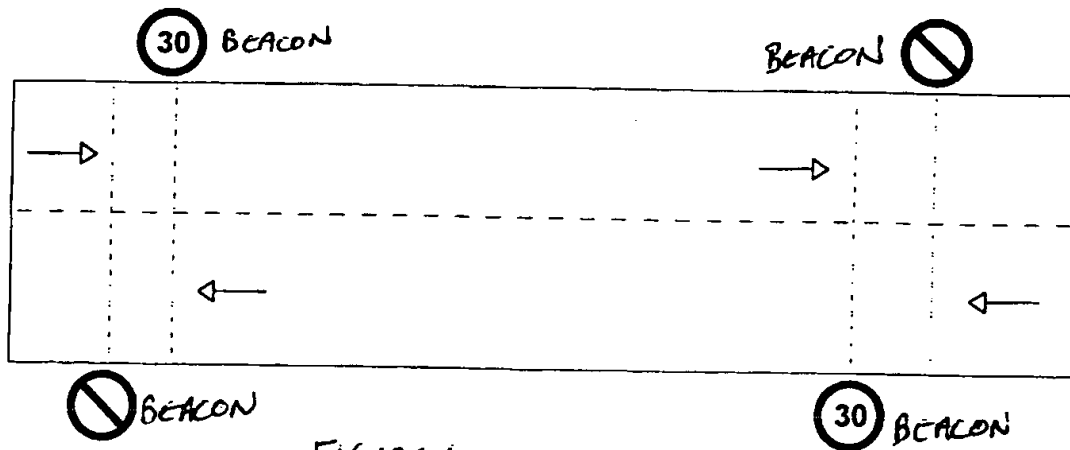


FIGURE 6

A Vehicle Speed Controller

The present invention relates to a controller for a vehicle engine which is designed to restrict the vehicle speed automatically within a zone in which the vehicle is travelling.

There is a widespread need to be able to ensure that vehicles adhere to speed limits especially within urban districts. There has been proposed methods of controlling vehicle speed by interrupting the throttle linkage of the vehicle. Such systems are largely mechanical and tend to be complex and expensive to fit to a vehicle. Such systems are also imprecise in their control of the vehicle speed.

The present invention seeks to provide a vehicle speed controller which is simple to install on a vehicle.

According to a first aspect of the present invention there is provided a controller for a vehicle engine, comprising a receiver means arranged to receive a signal from external to the vehicle and output a current-vehicle-speed-limit signal to a comparator arranged to compare the current-vehicle-speed-limit signal to a current-vehicle-speed signal and output a control signal which either indicates normal conditions if the current-vehicle-speed is less than the current-vehicle-speed limit or otherwise indicates control conditions, wherein the controller further includes a driver means which is arranged to receive the control signal and an input-torque signal indicative of a first engine torque and output an output-torque signal which in normal conditions is substantially similar to the input-torque signal or in control conditions is indicative of a

lower engine torque than the first engine torque. The present invention thus provides a controller which does not require any mechanical changes to the vehicle as the controller works in conjunction with the engine electrical systems. The present invention can be simply adapted to be fitted to most vehicles on the road.

The controller has advantageously the current-vehicle-speed signal generated from either ABS sensors on the vehicle, or calculated from GPS (global positioning data). In this way no additional sensors are required thus minimising the changes to the vehicle.

The current-vehicle-speed-limit signal may be transmitted to the vehicle from radio beacons. Alternatively, the current-vehicle-speed-limit signal is generated from GPS data in conjunction with an in-board database. Both methods provide accurate control of vehicle speed.

The database used in conjunction with the GPS data is updated from radio beacons. This reduces the memory requirement for the controller and allow the system to be updated at very regular intervals.

The controller preferably reduces the vehicle speed in a predetermined manner and thus avoids potentially dangerous rapid deceleration. The predetermined manner is preferably a progressive manner.

The controller advantageously reduces the vehicle speed in a predetermined manner dependent on the previous driving of the vehicle. This allows more driver freedom for responsible drivers.

The controller receives the signal from an engine management system of the vehicle to the fuel injectors which advantageously allows close control of the deceleration. With similar benefits the controller may alternatively receive a signal from the electronic throttle of the vehicle.

According to a second aspect of the invention there is provided one or more transmitters arranged to broadcast the current-vehicle-speed-limit signal received by the controller of the first aspect of the invention.

According to a third aspect of the present invention there is provided a method of controlling the speed of a vehicle including the steps of: interrupting a vehicle-torque-control signal, reproducing the control signal if the vehicle is travelling in a predetermined manner or inserting a vehicle-torque reduction signal if the vehicle is not travelling in the predetermined manner.

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings, in which:

- 25 Fig. 1 is a block diagram of a preferred embodiment of the controller of the present invention;
- Fig. 2 shows a schematic representation of the controller of the present invention;
- Fig. 3 illustrates two speed sensors used in conjunction with the controller of the present invention;
- 30 Fig. 4 depicts a fuel injector and the signal used to drive the injector;
- Fig. 5 illustrates the connection of the controller of

the present invention in relation to a vehicle engine management system; and

Fig. 6 illustrated transmitter placement of transmitters to be used in the present invention.

5

The controller 10 of the present invention is designed to reduce the speed of a vehicle automatically to the limit imposed within a zone. The invention is illustrated with
10 reference to a vehicle that has fuel injectors 20, but is equally applicable to vehicles using carburettors and an ignition coil by acting upon the low tension output from the coil.

15 The controller 10 of the present invention can be connected to almost any vehicle in the world. The system will connect to either the engine management system of modern cars or the ignition system on older vehicles with carburettors and no engine management. The speed of the
20 vehicle is determined via, for example, the anti-lock braking system (ABS) sensors or a speedometer sensor. Speed control transmitters would be placed by the roadside at points where speed control signs are and when the vehicle receives a coded signal relaying the speed limit
25 either an audible warning or visible warning will warn the driver before the system brings the car slowly down to the correct speed. The present invention allows for the speed to be reduced safely and smoothly as explained hereinafter.

30 The controller can be retro-fitted to 99% of cars on the road today. Average installation takes around 3 hours.

As shown in Fig. 1 and Fig. 2, the controller 10 includes

a receiver 12 to receive a signal from one of a variety of sources, for example: radio beacons; global positioning satellites; infra-red links; and ultrasonic links.

- 5 The controller 10 also includes means to receive a signal indicative of the vehicle current speed. The speed will normally be measured by one of the following three ways:
 1. using an ABS sensors 22 already fitted to the vehicle (as shown in the illustrated embodiment);
 - 10 2. using a road speed sensor already fitted to the vehicle; and
 3. using a calculated speed computed from the global positioning system (GPS).
- 15 The controller 10 includes a comparator 14 which compares current vehicle speed to the speed limit within the zone. The comparator 14 outputs a signal to an injector driver 16 to depending on whether or not the vehicle is travelling over the speed limit for the zone. If the vehicle is
- 20 travelling below the limit then these are herein referred to as normal conditions and if the vehicle is travelling above the vehicle limit then these are referred to herein as controlled conditions.
- 25 The injector driver 16 is the device which interfaces with the injector circuits 24 in the vehicle electronics systems. The injector driver 16 receives the input-torque signal directed to each injector 24 from the engine management system 26. In normal conditions the input-
- 30 torque signal is replicated and the replicated signal output as the output-torque signal. In controlled conditions the output-torque signal is produced to reduce the torque produced by the engine in a preset manner;

normally the torque will be gradually reduced to effect gradual slowing down of the vehicle.

The controller 10 thus limits the power of the engine until
5 the car speed is reduced to below the limit within the zone.

The controller 10 is normally connected in the following fashion. Once the polarity of the fuel injection system
10 has been determined, the signal wires 24 feeding each fuel injector must be cut and the injector cut loom connected as shown in Fig. 4. Then each wire from the controller 10 is connected to each of the injector signal wires as follows. Cut the signal wire 24 and strip each end exposing the
15 cores. Tin each of the exposed wires using the soldering iron and solder. Solder the first input wire to the signal wire on the engine control system 26 (ECS) side. Solder the first output wire to the signal wire 24 on the fuel injector 20 side. Cover both joints with heat-shrink.
20 Repeat the process for each of the signal wires 24.

In vehicle with an anti-lock braking system 28 (ABS) the sensors 22 can be used as speed detectors for the controller of the present invention. As shown in Fig. 3,
25 most ABS sensors 22 are passive inductive sensors that give a signal when metal passes through the detector; the resistance of sensors normally varies from 800 - 1200 ohms.

30 Sensors 22 are usually two wire which account for eight wires feeding the ABS unit 28. These wires have to be located and four wires from the controller 10 have to be connected to one side of each sensor 22 as shown in Fig. 3.

For sensor 22A, one of the wires is connected to the shielding of the cable and the controller wire must be connected to the wire connected into pin 111. For sensor 22B, both wires carry signals to the ABS 28 and so the controller 10 can be connected to either wire 111, 112.

The global positioning system (GPS) is known to those skilled in the art. The global positioning system (GPS) now available offers further advantages. Firstly no radio beacons are required, and secondly the speed of the vehicle can be measured using the global position data removing the need for speed sensors. This will allow trials of the system to be speedily set up in a simple fashion.

There are a number of standard receivers used to interpret the GPS signals from the collection of satellites used for global positioning. These receivers allow determination of a vehicle position to within about 50-100 meters. To increase the accuracy of the positioning, a differential radio receiver unit may be connected to the GPS receiver, and this will improve the accuracy to about 10 meters.

Normally a standard GPS receiver 12 will be used in the controller 10 of the present invention. The GPS receiver 12 will communicate with the comparator via a standard serial RS232 communication.

The controller 10 is programmed with the location of all the speed limit zones, and when the vehicle passes into those zones, the controller 10 sends a signal to the signal driver 16 and this slows down the vehicle if necessary. The information available from the GPS system can be used to calculate speed, therefore obviating the need for a

separate speed sensor 22 input.

Injector cut works by taking the signal supplied to each fuel injector 20 and feeding it into the controller system
5 10. Under normal running the signal is reproduced exactly firing the fuel injectors 20 as normal. When overspeed is detected the speed control shuts down each fuel injector 20 independently reducing the power of the engine progressively. The severity of the cut is dependent upon
10 the amount of overspeed detected and the parameters held within the controller 10.

Normally an injector 20 will have two wires which are connected thereonto. One of the wires 24 supplies 12 V and
15 the other supplies a 12 V signal going down to ground to fire the injector 20 as shown in Fig. 4. It is these signal wires 24 that are connected to the speed controller 10 of the present invention.

20 The signals produced by the vehicle engine management system 26 of the illustrated embodiment is interrupted by the controller 10 of the present invention. Under normal conditions the controller 10 reproduces the original signal and transmits this to the injectors. When power (speed)
25 reduction is made i.e. under controlled conditions, a selective program of shutting down the fuel in separate cylinders is instigated. This method is safe on emissions, catalysts and engine wear, and is relatively smooth in its operation.

30

The signal originating from the engine control unit (ECU) 26 to drive the fuel injectors expects to see a resistive load in the order of 4-18 ohms. This signal is broken in

the control system of the present invention. A dummy load is provided in order to allow the ECU 26 to continue to function normally.

- 5 In the illustrated embodiment, the dummy load consists of a 47 ohm, 6 watt wire wound resistor, one end connected to 12 volts and the other to the wire from the ECU. The ECU shorts this wire down to ground, normally driving the injector 20 into opening and delivering the fuel. The
- 10 signal from the ECU 26 can then be smoothed through a resistor and capacitor network, reduced down from a 12 volt signal to a 5 volt signal by using a Zener Diode, and then cleaned up using a Schmitt Trigger inverter. The resulting clean signal is fed into a microprocessor that measures the
- 15 signal duration. The microprocessor will reproduce this clean signal and output the reproduced signal to an injector driver circuit if no power limitation is presently required.
- 20 When the microprocessor has to limit the power of the engine (in controlled conditions), it does so by shutting down the injectors 20 in varying degrees. The shutting down of the injectors 20 has to be timed, so as to prevent a reduction in the opening duration of the injector 20. If
- 25 the injector opening is only reduced and not completely shut off, the engine will run lean and damage can occur to the engine. The signals going to the fuel injectors are pulse width modulated signals, with separate gaps between each firing. The microprocessor waits for these gaps
- 30 before it shuts down the injector 20, thus the injector 20 can only be turned off after a complete cycle has taken place, and not during a timed fuel delivery. An incomplete delivery would mean less fuel than normal enters the

combustion chamber, causing a lean burn, high temperature situation. The current invention adopts a power reduction by missing one complete cycle during which the engine receives only air, and cannot ignite, thus no build up in
5 heat can occur.

In vehicles having exhaust gas catalysts the missing burn cycles can start to cool the catalyst down, losing it's efficiency. When the fuel is regularly being injected into
10 the inlet plenum, the walls of the plenum stay wet with fuel. When the engine has been sucking air through the plenum without any fuel added, the walls are scavenged of their excess fuel, and the next fuel pulse that comes
15 through is robbed of a percentage of it's load to re-wet the walls of the plenum. In a particularly preferred embodiment of the present invention, this is remedied by adding a small amount of fuel to the next pulse sent to that injector and this extra fuel will burn in the catalyst, raising the catalyst temperature back to normal.
20 Furthermore, adding an additional amount of fuel to the next fuel pulse will also allow re-wetting of the plenum.

In cases where the vehicle has fuel injectors 20 the following 'injector cut' method is utilised. This
25 progressively shuts down the fuel injectors. An injector 20 can be turned completely off, or set to miss out a particular pattern of pulses.

Eg. Acting on a single injector

| | | | | | | | | | | |
|----|---------|-----|----|----|-----|-----|----|-----|----|------------|
| 30 | Pulse | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | %reduction |
| | Level 0 | on | on | on | on | on | on | on | on | 0% |
| | Level 1 | off | on | on | on | off | on | on | on | 25% |
| | Level 2 | off | on | on | off | on | on | off | on | 33% |

| | | | | | | | | | |
|---------|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Level 3 | off | on | off | on | off | on | off | on | 50% |
| Level 4 | off | off | on | off | off | on | off | off | 66% |
| Level 5 | off | off | off | on | off | off | off | on | 75% |
| Level 6 | off | off | off | off | off | off | off | off | 100% |

5

Thus for each injector 20 there are at least 6 levels of cut you can instigate that will reduce the power of the engine in stages. For many engines there are a number of injectors 20, so once level 6 has been reached on one injector 20, the next injector 20 is acted upon, and so forth until all the injectors 20 are turned off. This allows the power of the engine can be progressively shut down in small stages.

15 For example in a four cylinder car, level 1 cut on 1 injector 20 will give a power reduction of 25% divided by the number of cylinders (=4). This equates to a 6.25% reduction in power. A level 3 cut on all injectors 20 will give a 50% reduction in power.

20

To achieve a safe reduction in engine power when the limit is exceeded, these levels of cut are progressively applied over a set time limit.

25 When the car is cruising at the set limit, a different algorithm is used. The amount of cut applied to the engine is dependant on the amount of torque the engine is producing. A closed loop system is utilised to maintain an accurate speed independent of how much throttle the driver applies. This closed loop system uses a PID (Proportional Integral, Differential) loop to maintain the speed of the vehicle.

30

As will be apparent from the foregoing, the system can be thought of as a box going between the ECU and the engine, controlling the power of the engine from 0 - 100% depending on a signal is receives from the speed control unit.

5

Alternatively, in cases where there is no fuel injector, an ignition coil interface is used. This is similar to the injector cut method except the ignition coil is utilised. This system is only used on old cars with carburettors and
10 without catalyts. Any car running on carburettors will not be using a catalyst.

In some cars there is an electronic throttle, in which case an electronic throttle interface is used. Electronic
15 throttles tend to limited to top of the range modern cars such as BMW's, Mercedes, Jaguars, etc. The interface is again similar to the injector cut interface to these systems to back off the throttle when requested.

20 On diesel cars with no electronic injectors, an engine management interface is used where possible, or an electronic cut out solenoid on mechanical systems.

The absolute speed of the vehicle is normally measured
25 using one of three methods. The first method is to take a signal from wheel speed sensors attached to the hubs of the vehicle, as used in ABS systems. The second is to use a signal taken from the speedometer of the vehicle. The third is to use the information from the GPS system to determine
30 speed.

To use a wheel speed sensor to measure the vehicle speed, the pulses coming from that sensor are timed from one to

the next to work out their frequency. From the stored information containing the size of the wheel, and the number of pulses for each revolution, the speed of the wheel is calculated. The absolute speed of the vehicle is
5 taken as the slowest signal coming from the speed sensor, e.g. the ABS system.

The second method is only used in situation where the first and third methods are unable, normally in the case of older
10 vehicles.

In the GPS method, the absolute Latitude and Longitude of the vehicle is known at a precise time. Two such readings can be subtracted to give distance travelled over time.
15 This can then be used to work out vehicle speed.

This signal is then compared to the current speed limit value and if the vehicle speed is greater than the speed limit, the power of the engine is reduced. The current
20 speed limit can be set by two means, radio transmitters and using the global positioning system.

Radio transmitters to be used are placed along the roadside at each new change in speed limit. Each transmitter
25 broadcasts a radio code containing data that is unique for each speed limit. These transmitters can be in two forms, the first being a stand alone unit that radiates in a limited sphere around the beacon using an aerial mounted above ground, and the second being a buried cable under the
30 road that works in close proximity only. The first form is particular easy to install. However, the second the most effective and discriminating, for example, if there are two roads close together, no zone overlap will occur with a

wire under the road, but two aerials mounted above ground may interfere with each other in close proximity.

5 A radio receiver 12 on board the car receives from the transmitter the code and translates this into a speed limit value to compare with the vehicle speed.

10 The second method is to use a Global Positioning system receiver mounted within the car, and using an external aerial to pick up satellite data. The Latitude and Longitude of the receiver 12 is transmitted to the controller and used to reference a database stored in the controller. This database can be in various forms, for example: a digitised map of the country with marked areas
15 of speed zones, or a reference point of every speed limit sign, and its area of influence.

The information could be stored on CD-ROM, Flash memory or any other electronic media. The information could be
20 updated by approved Government sites, for example at each MOT or other vehicle inspection. Another method is to have localised radio transmitters transmitting up to date information on a set area, say 100 square miles, and this could be picked up and stored in the controller unit and
25 used whilst in that area. This would save memory, and would also be the most up to date method of application to ensure that the vehicle is using data on the present road layout and current vehicle speed limits.

30 The remote control limiters used work by having a stationary transmitter sending out a constant signal and constant signal is received by a portable unit attached to the vehicle and instigates a speed limiter.

One method illustrated in Fig. 6 of slowing cars down coming into a town, and speeding them up as they exit can be carried out by having two aeralals at each zone change, the ones furthest outside the speed limit zone transmit no
5 limit signals (or a limit appropriate to that area), and the inner ones the 30 mph limit. When a car enters a town, first it receives a no limit signal, which doesn't affect it, then it reaches a 30 mph signal, which slows the car down. As the car exits the zone, it firstly receives a 30
10 mph signal, which again doesn't affect it, and the a no limit signal which speeds the car back up again. This will then work in either direction.

The receiver 12 continuously activates a speed limit until
15 it receives a no limit signal. This has a memory backup, so if a car enters a 30 zone, the engine is switched off, and then back on again, it does not lose this speed limit.

The controller can be provided with additional features.
20 For example, an in car rotary adjuster could be utilised to select a desired speed limit, eg. 30mph 40mph 50mph 60mph or 70mph.

There could be a built in safety feature whereby a safe
25 overtake could be included, maybe a time limit for an overspeed condition, or an override for full throttle.

Additional the following features can be incorporated:-

1. Police cars with directional aeralals can pick on a car
30 within 0.5 km and selectively slow it down.
2. A cellular link whereby an operator taps in the number plate of a vehicle which then slowly reduces speed. This could be tied into either the brake lights or the

hazard warning lights.

3. The controller can be adapted to provide an upper speed limit as well, e.g. for parents concerned about children just passing their test.

5

The system may be advantageously used in the following situations:-

1. On the motorway in fog, or before a blocked carriageway, the cars could be limited down in unison a long way before the accident;
- 10 2. Accident blackspot areas;
3. Schools & Hospitals to implement part time speed restrictions;
4. Racing circuits could allow pupils out in their cars, and slowly raise the speed of all their cars as the pupils learn.
- 15

One main concern of using the remote control limiter technology is the driver driving up against the speed limiter all the time. The present is adaptable to form a system that is almost transparent to the driver, only coming into effect when strictly necessary.

20

Rather than a pure speed limiter that comes in every time at a set speed, what is proposed is a system that assesses a drivers style, and reacts accordingly. If a driver always obeys speeds limits, the limiter can be set out of the way of normal driving, the theory being he should never know of it's presence. Under normal driving conditions, it may allow a little latitude to such a driver. If a driver consistently attempts to speed, the device comes in very strictly, until the driver is almost re-educated into obeying speed limits, thereafter the system can sit 'out of

25

30

the way' monitoring the driver's style. In other words, if he doesn't notice a limit change, or becomes over enthusiastic, the system steps in and reduces the car to the set limit.

CLAIMS:

1. A controller for a vehicle engine, comprising a receiver means arranged to receive a signal from external
5 to the vehicle and output a current-vehicle-speed-limit signal to a comparator arranged to compare the current-vehicle-speed-limit signal to a current-vehicle-speed signal and output a control signal which either indicates normal conditions if the current-vehicle-speed is less than
10 the current-vehicle-speed limit or otherwise indicates control conditions, wherein the controller further includes a driver means which is arranged to receive the control signal and an input-torque signal indicative of a first engine torque and output an output-torque signal which in
15 normal conditions is substantially similar to the input-torque signal or in control conditions is indicative of a lower engine torque than the first engine torque.
2. The controller according to claim 1, wherein current-
20 vehicle- speed signal is generated from either ABS sensors on the vehicle, or calculated from GPS (global positioning data).
3. The controller according to claim 1 or claim 2,
25 wherein the current-vehicle-speed-limit signal is transmitted to the vehicle from radio beacons.
4. The controller according to claim 1 or claim 2,
wherein the current-vehicle-speed-limit signal is generated
30 from GPS data in conjunction with an in-board database.
5. The controller according to claim 4, wherein the database is updated from radio beacons.

6. The controller according to any one of the preceding claims, wherein the controller reduces the vehicle speed in a predetermined manner.

5 7. The controller according to claim 6, wherein the predetermined manner is a progressive manner.

8. The controller according to any one of the preceding claims, wherein the controller reduces the vehicle speed in
10 a predetermined manner dependent on the previous driving of the vehicle.

9. The controller according to any one of the preceding claims, wherein the controller receives the signal from an
15 engine management system of the vehicle to the fuel injectors.

10. The controller according to any one of claims 1 to 8, wherein the controller receives a signal from the
20 electronic throttle of the vehicle.

11. An internal combustion engine for a vehicle including a controller according to any one of the preceding claims.

25 12. A vehicle including the internal combustion engine according to claim 11.

13. One or more transmitters arranged to broadcast the current-vehicle-speed-limit signal received by the
30 controller of any one of claims 1 to 10.

14. A kit comprising the one or more transmitters of claim 13 and a controller according to any one of claims 1 to 10.

15. A method of controlling the speed of a vehicle including the steps of: interrupting a vehicle-torque-control signal, reproducing the control signal if the
5 vehicle is travelling in a predetermined manner or inserting a vehicle-torque reduction signal if the vehicle is not travelling in the predetermined manner.

16. A controller as hereinbefore described and/or as
10 illustrated in the accompanying drawings.

17. An internal combustion engine as hereinbefore described and/or as illustrated in the accompanying drawings.

15

18. A vehicle as hereinbefore described and/or as illustrated in the accompanying drawings.

19. A transmitter as hereinbefore described and/or as
20 illustrated in the accompanying drawings.

20. A kit comprising one or more transmitters and a controller as hereinbefore described and/or as illustrated in the accompanying drawings.

25

21. A method of controlling the speed of a vehicle as hereinbefore described and/or illustrated in the accompanying drawings.



Application No: GB 9801543.1
Claims searched: 1 to 10, 14 and 16

Examiner: Tom Sutherland
Date of search: 22 June 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): B7H (HXB, HXD, HXG, HXJ); G3R (RBN29)

Int Cl (Ed.6): B60K 31/00

Other: Online: WPI. EPODOC, JAPIO

Documents considered to be relevant:

| Category | Identity of document and relevant passage | Relevant to claims |
|----------|---|--------------------------|
| X | GB 1147459 (LOWE) See page 2 line 85 onwards for example. | 1, 3, 6 and 7 |
| X | EP 0745965 A (EQUOS) See Fig. 1 and column 4 lines 25 to 38. | 1, 4, 6, 9 and 10 |
| X | EP 0697301 A (MACCAFERRI) Whole doc relevant. | 1, 3, 6 and 14 at least. |
| X | US 4216520 (CITROEN) Whole document relevant. | 1 and 3 |
| X | US 4166514 (CITROEN) Note Figs 1 and 2 and column 4 lines 4 to 34.. | 1, 3, 6 and 10 |
| X | US 4068734 (FOELLER) Note column 4 line 3 to column 5 line 15. | 1, 6 and 7. |

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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